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THE EUROPEAN PINE SHOOT MOTH Rhyacionia buoliana SCHIFF.

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Discovery of the European pine shoot moth on red pine at Bellevue, Washington, in May 1959 added another destructive foreign insect to the list of forest pests in the Pacific Coast States. The possibility that the shoot moth may spread to the ponderosa pine region and thrive there must now be recognized and weighed against the possibility of extermination. In considering these possibilities, there is need for information regarding the insect, its present distribution, the damage it causes, and the available means for controlling it. The following information has been extracted largely from the extensive literature on the shoot moth in eastern states and Europe.

Establishment and Distribution in North America

The pine shoot moth was first found in North America in 1914, infesting Scotch pine in New York State. A year later a survey indicated that the insect was present in at least ten states and a federal quarantine was placed on the importation of pines from Europe. Early attempts to develop a detection and eradication program failed, and the insect subsequently spread into many forest plantations, city plantings, and nurseries. At present it is generally distributed along the eastern seaboard from Florida into southern New England, in the Central States, the Lake States, and southern and eastern Canada. Some eastern states have imposed quarantines to aid in control. In the West, it was found in 1927 to be heavily infesting mugho and Japanese red pine in a nursery near Victoria, B. C., on Vancouver Island. The infested pines were destroyed and the moth was not again reported in the province until 1938 in the City of Vancouver. Another ambitious eradication program was undertaken. Since then, the shoot moth has been recorded in Vancouver in 1941 and 1943 and in Victoria in 1956 and 1958.

Host Trees

This insect is primarily a pest of young trees. Red, mugho, and Scotch pines are attacked most severely. Other favored hosts are Austrian, jack, and Japanese red pines. Ponderosa pine is attacked in this country, but little is known about its susceptibility to attack and ability to withstand injury in its native environment. In experiments in the Lake States it was intermediate in susceptibility. In European plantings, it suffers heavy attacks. The white pines are only lightly attacked in America, but are heavily attacked in Europe.

Description of the Insect

The adults are small buff-colored moths with a wing expanse of  $3/4$  inch. The forewings are orange to brownish red, marked with six irregular silvery cross lines, and the hind wings are dark brown. The larvae grow to be  $5/8$  inch long, and are reddish brown in color with black heads and collars. The pupae are about  $3/8$ -inch long, robust, dark yellow brown, with rows of small dark spines on the abdomen. Eggs are only  $1/32$  inch long, flattened, oval in shape, and change from light yellow to a light brown during development.

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### Life History

There is one generation a year in America, as in Europe. Adults appear late in spring and fly during the night. Eggs are laid singly or in groups of 2 to 10 on the tips of the twigs - on the stem, on needle fascicles, or at the base of buds. The upper part of the tree is preferred for oviposition. Hatching larvae bore into the fascicle sheaths, after building a protective silken tube. About mid-summer the larvae bore into buds where they remain for the rest of the summer and through the winter. In spring, larvae leave the buds in which they overwintered and attack uninfested buds or expanding shoots. Buds are normally killed while shoots are usually malformed, subsequently causing a crook known as a posthorn. Upon completing feeding, larvae pupate in tunnels in the buds or new growth. After 2 to 3 weeks, the pupae wiggle out of the tunnel until mainly exposed, and the adults emerge.

### Evidence of Feeding and Injury

The presence of larvae is indicated by small globules of resin on the buds, accompanied by dead needles resulting from the early mining of the needle bases. Previous injury is shown by bushy growth on the leader and ends of the branches, forking of the leader, stunting of the trees, and distortions of the leader into a "posthorn" or "bayonet tip". Sometimes a severe infestation may result in conspicuous defoliation of the upper part of the trees. Under conditions favorable to the insect, complete stagnation of tree growth takes place. In some states, planting of favored hosts such as red pine is discouraged.

### Conditions Favoring Damage

As with most introduced insects, the pine shoot moth arrived in this country unaccompanied by its natural enemies. Most infestations have originated from the planting of infested nursery stock, and the planting of such stock from eastern nurseries is a continuing source of infestation in the West, so long as it is allowed in the trade. Local dispersion up to a few miles may result from moth flights, but long distance spread by this means is believed not to occur. Whether the strong air currents in the mountains of the West may result in wider natural dispersion remains to be determined. To date, spread from forest plantations into natural stands of native pines has not been recorded.

In general, the rise of an infestation and its severity depend upon the species of pine, the height of the trees and stand density. On a favored host it takes 3 to 5 years for a severe infestation to develop. All young pines below a height of 20 to 25 feet, grown in the open, are susceptible to attack. Once the trees attain a height of 25 feet or once the stand closes sufficiently so that the lower branches die off, the trees are reasonably safe from damage.

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#### Survey

Infestation can be most readily detected late in summer when the discoloration of the needles on the infested shoots is most conspicuous. Detection of light infestations is difficult and is complicated by the fact that damage by other insects, such as the pitch nodule moth, the Zimmerman pine moth and related but unimportant species of Rhyacionia, may be confused with that of the shoot moth. A survey for determining the extent of infestation and the practicability of eradication would have to be made by adequately trained individuals.

#### Control

Native parasites cause only small reductions in shoot moth populations. Three parasites introduced from Europe into the eastern states have been more effective, but cannot reduce damage perceptibly unless the spread of the shoot moth is retarded by care in planting susceptible pines. While epidemics do occur in Europe, they are effectively controlled by the natural control factors in combination with careful cultural practices.

Cold winters are effective in reducing shoot moth populations and in limiting the range of the insect. A minimum temperature of -15 degrees F. occurring every 3 to 5 years, is cited as preventing serious population increase. Thus, minimum winter temperatures are likely to keep the shoot moth from becoming a serious pest in portions of the ponderosa pine region.

Removal of infested shoots in spring is effective in controlling the shoot moth on isolated ornamentals. Use of this method in plantations is not usually practical because of the cost, and not effective unless all infested trees in the plantation and the immediate vicinity are treated.

Artificial control by spraying has been attempted for many years. Timing of the spraying with the period from a week before to a week after the hatching of eggs or with the resumption of larval activity in spring is necessary for effective control. Drenching the trees is necessary in order to get the insecticide deposited at the bases of the needles and on the buds. At present spraying is considered too expensive to be practical in forest plantations. The following equipment and insecticide formulations have been recommended: (1) hydraulic sprayer using 1 to 2 pounds of DDT per 100 gallons of water or 4 pounds of ground cube root with one pound of powdered skim milk as a sticker in 100 gallons of water; (2) mist blower using 1 gallon of 25 percent emulsifiable DDT concentrate per 9 gallons of water. With the latter, 50 gallons per acre are required to obtain 90 percent reduction of shoot moth populations on trees 4 to 6 feet tall. Helicopter and airplane spraying have been attempted on an experimental basis, but results have not been satisfactory.

Prevention of spread of the shoot moth from nurseries is an important step in control. Annual inspection of young pines during late summer or fall will disclose whether or not the insect is present. If so, artificial control should be applied as a routine measure. Fumigation of dormant planting stock prior to shipment is important if a nursery is known to be even lightly infested. Use of methyl bromide to treat baled seedlings in a fumigation chamber is very effective at a reasonable cost.

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